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(54) **Expanding-pulley gearing**

(57) A transmission assembly has an adjustable V-pulley (1) mounted for rotation with an input shaft (4) and an adjustable V-pulley (2) mounted for rotation with an output shaft (11). The pulleys (1 and 2) are interconnected by either a metallic chain or a rigid metallic annular ring. A centrifugal ball governor (17) which is responsive to the rotational speed of shaft (14) controls the axial position of half sheave (12) of pulley 2 in association with biasing of the half sheave (5) of pulley (1) by spring (8) to vary the radii R1 and R2 at which the transmission member drivingly engages the pulley drive faces (15). The pulleys (1 and 2) and endless member (16) are mounted in sealed housing (24) which contains traction fluid such as a cycloaliphatic synthetic hydrocarbon.

The assembly can be used to maintain the rotational speed of the output shaft (11) substantially constant when the input shaft (4) is rotated at a speed variable within a predetermined range.

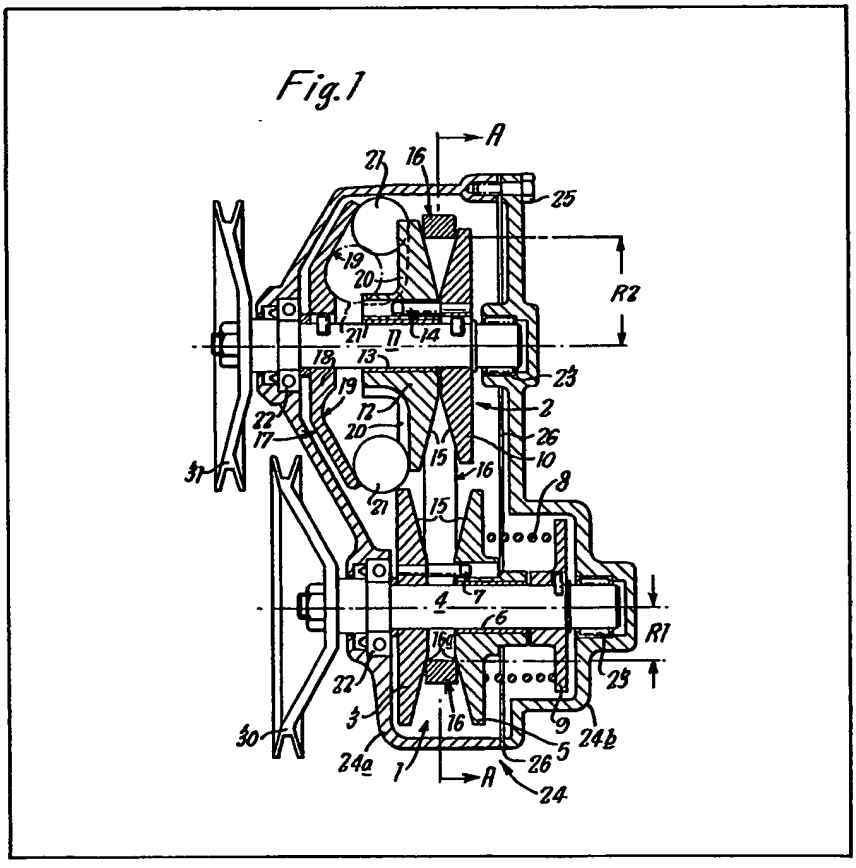

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Fig.1

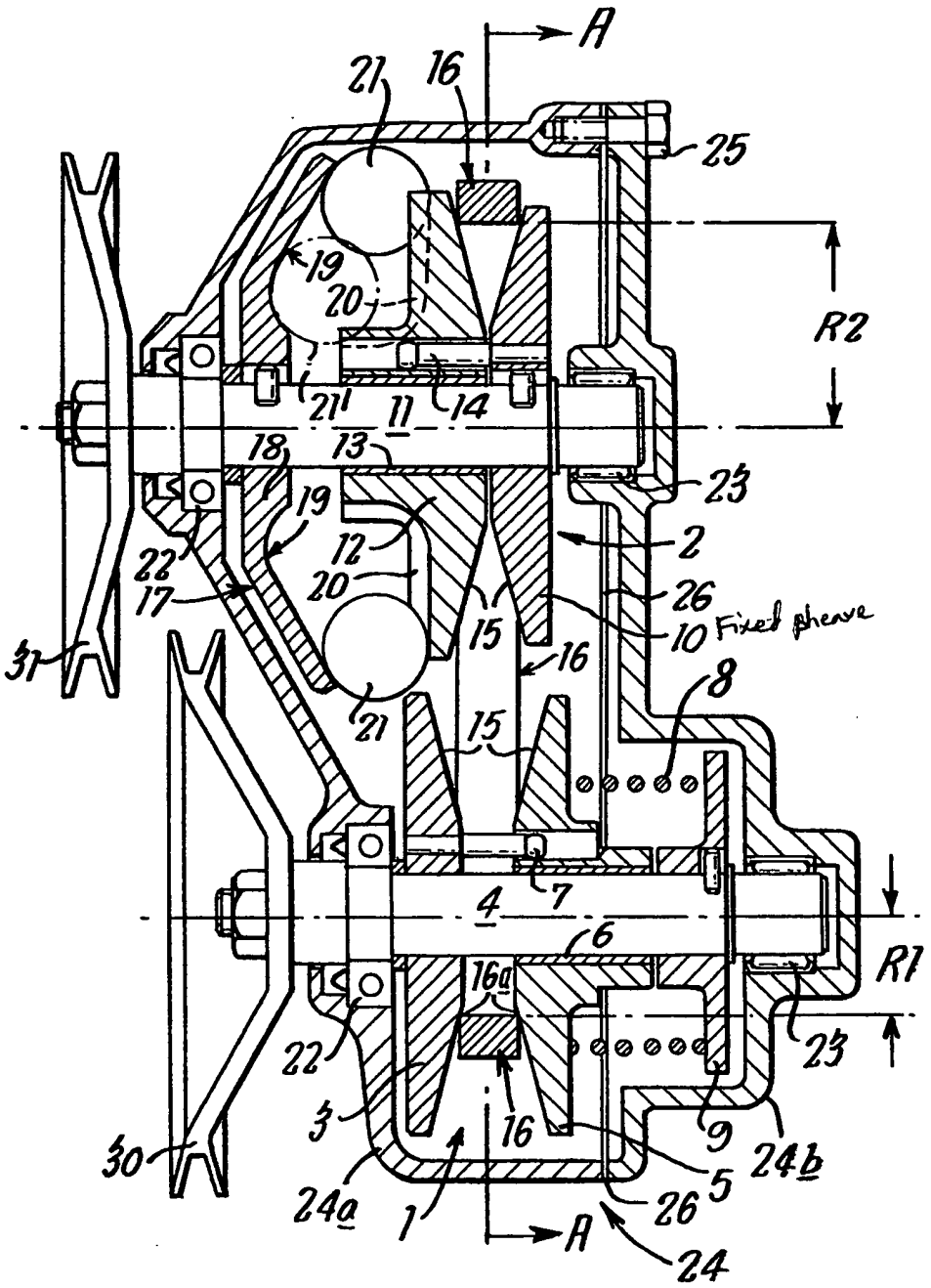

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Fig. 2

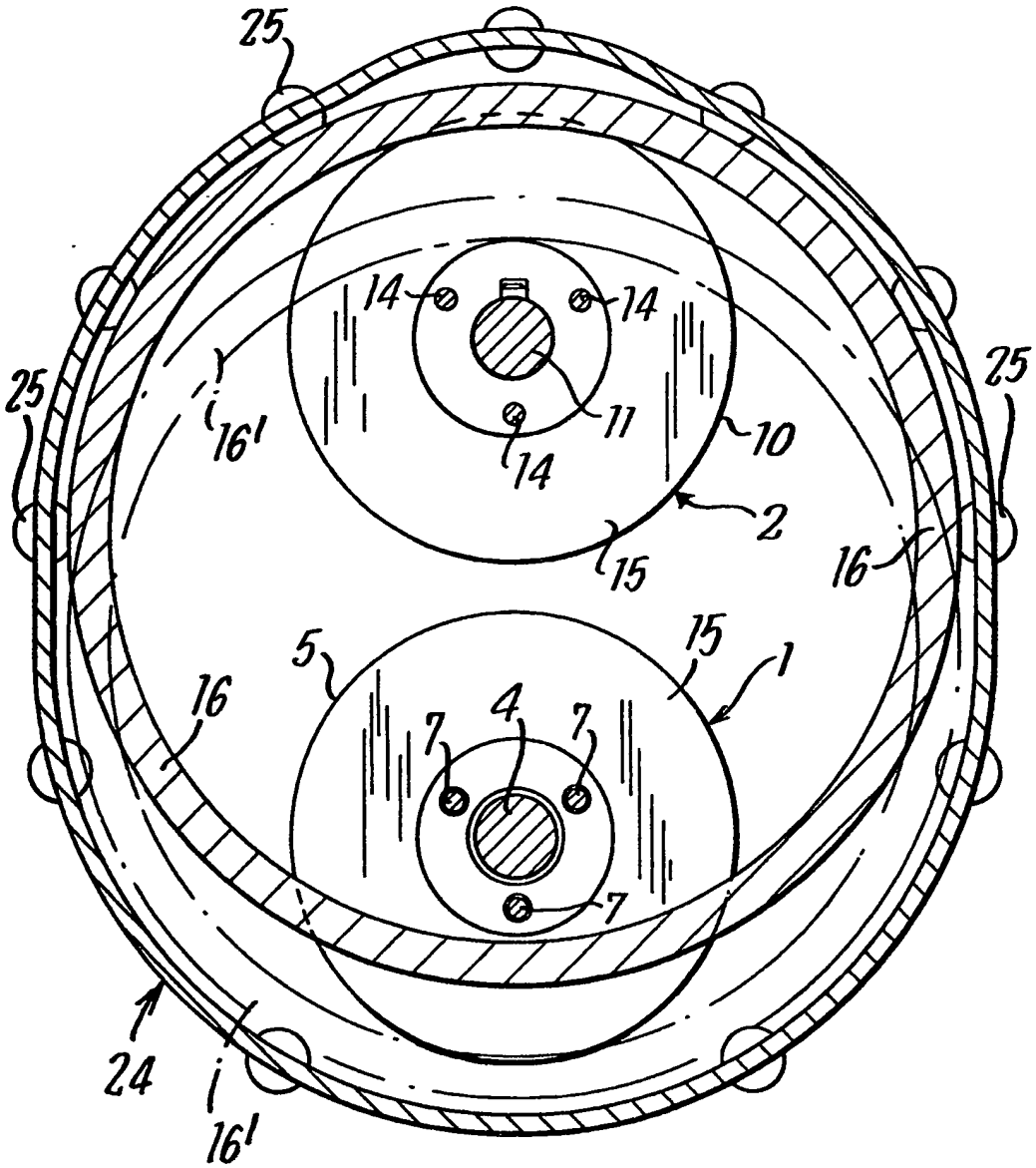

Fig.3

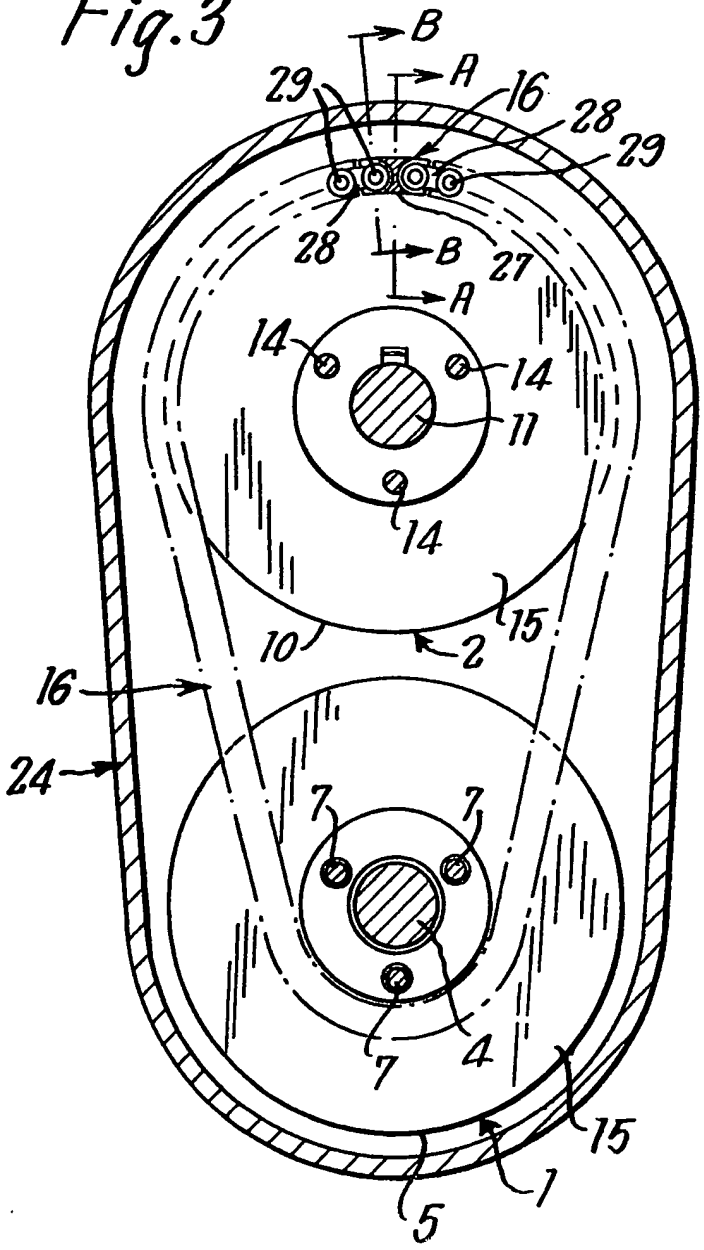

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Fig. 4

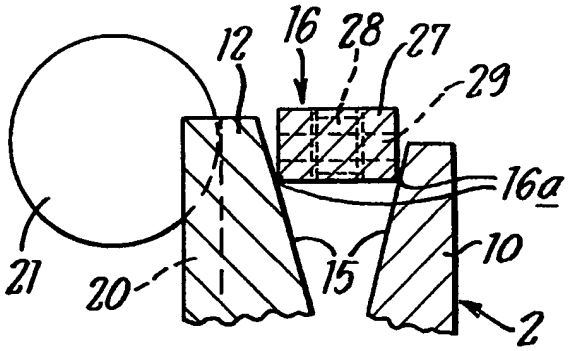
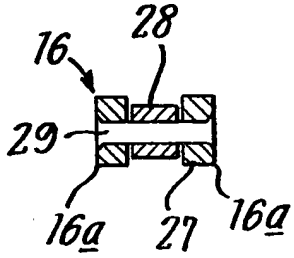


Fig. 5



SPECIFICATION

Improvements in or relation to transmission assemblies

This invention relates to a transmission assembly.

More particularly, the invention concerns a transmission assembly comprising two V-pulleys one being mounted for axial rotation with a first shaft and the other being mounted for axial rotation with a second shaft, an endless transmission member which is maintained under tension and interconnects the two pulleys to provide driving engagement therebetween; each pulley comprising two half sheaves at least one of which is axially displaceable relative to the other; governor means which is responsive to the speed of rotation of the first pulley and controls the axial spacing between the half sheaves of that pulley, and spring means associated with the second pulley which biases the half sheaves of that pulley axially towards each other for the second pulley to accommodate radial displacement of the transmission member resulting from the variation in the axial spacing of the half sheaves of the first pully by the governor means so that the transmission member is maintained under tension and in driving engagement with both pulleys while the ratio at which drive is transmitted from one pulley to the other is variable by the radial displacement of the transmission member relative to both pulleys. Such a transmission assembly will hereinafter be referred to "as of the kind specified".

A transmission assembly of the kind specified is the subject of our U.K. Patent Specification No. 1,426,351, and in this disclosure and also in conventional transmission assemblies of the kind specified the endless transmission member is in the form of a flexible belt which is usually moulded or otherwise shaped to present a "V" profile for mating in substantially face-to-face relationship with the respective pulleys. Such a belt of appropriate elastomeric or resilient material and often having wire or fabric reinforcement is subjected to considerable wear during use. As a result of this wear the material of the belt can break down (causing the belt to stretch or its frictional characteristics to alter) to the extent that the useful life of the belt during which efficient drive with predetermined characteristics between the two shafts of the assembly can be for an unreasonably short period. It is an object of the present invention to provide a transmission assembly of the kind specified which alleviates the difficulties aforementioned which are associated with belt drive assemblies.

According to the present invention there is provided a transmission assembly of the kind specified in which the endless transmission member is of a substantially rigid metallic material and is in the form of a chain or annular ring member and wherein the two V-pulleys are mounted in a sealed housing containing a traction fluid and said transmission member is in traction driving engagement through said fluid with both pulleys.

The metallic structure of the endless transmission member of the present invention renders it with a considerably longer life than that of conventional belts. Furthermore, by providing traction drive between the transmission member and the pulleys wear between the drive surfaces of the pulleys and the transmission is alleviated so increasing the life of these components while efficient drive is maintained through the traction fluid. The principle of traction fluids is well known and in the context of the present invention a film of the fluid forms between the pulleys and the transmission member which film, upon relative displacement between the pulleys and the transmission member during the transmission of drive, becomes highly viscous to form a link between the transmission member and both pulleys. A suitable traction fluid for use in the assembly of the present invention is a cycloaliphatic synthetic hydrocarbon fluid, for example that made by Monsanto Limited and sold under the Trade Name "Santotrac".

Preferably the endless transmission member engages through the film of traction fluid with each half sheave along a substantially arcuate line. By this latter arrangement the transmission member may be substantially rectangular in section taken in a plane which includes the axes of the two shafts thereby alleviating the generally V-shaped sectional profile of belts in conventional assemblies (where maximum area of face-to-face contact is sought between the V-shaped surfaces of the belt and the drive faces of the pulleys).

While the metallic transmission member of the present invention is easily formed as an annular rigid ring of, for example, steel it is appreciated that the diameter of such a ring may necessitate an unreasonably large housing for its accommodation. More conveniently therefore from the point of view of compactness the metallic transmission member will usually be in chain form. Desirably the chain is formed of pivoted links which are rigidly interconnected in the sense that the deformable loop of the chain is maintained in a substantially flat plane whereby the surfaces or edges of the chain which are presented for driving engagement through the traction fluid with the pulleys are constant.

In use of the assembly of the present invention one of the shafts will form a driving shaft while the other will be a driven shaft and the characteristics of the transmission which is possible between these shafts by relative displacement of the respective half sheaves in the two pulleys and corresponding radial displacement of the endless transmission member can be various, for example as discussed in our aforementioned U.K. Specification No. 1,426,351. Preferably however the assembly is arranged to provide the driven or output shaft with a substantially constant speed of rotation when the driving or input shaft is rotated at any speed within a predetermined range; such a construction is particularly useful in, for example, motor vehicles where the input shaft may be coupled to be driven at a speed which cor-

responds to the speed of the vehicle engine while the output shaft is maintained at a substantially constant speed for driving engine auxiliaries such as a water pump or generator.

The governor will usually be centrifugally actuated, for example, in the form of caged balls which rotate with the shaft with which the governor is associated and are displaced radially over ramps in accordance with the speed of rotation. Such radial displacement of the balls will cause, directly or indirectly, the half sheaves on that shaft to be axially displaced relative to each other and thereby an adjustment to be effected in the radial positioning of the endless transmission member to vary the ratio at which drive is transmitted between the two pulleys – it will be appreciated that alternative forms of centrifugal governor or other speed responsive governors can be utilised.

Embodiments of a transmission assembly constructed in accordance with the present invention will now be described, by way of example only, with reference to the accompanying illustrative drawings, in which:–

Figure 1 is a sectional side elevation of a first embodiment of the assembly in which the endless transmission member is in the form of a rigid annular steel ring;

Figure 2 is a section of the assembly shown in Figure 1 taken on the line A-A in Figure 1;

Figure 3 shows a section through a second embodiment of the assembly which section is similar to that shown in Figure 2 and in which the endless transmission member is in the form of a chain;

Figure 4 is a partial section through the assembly of Figure 3 taken on the line A-A of Figure 3, and

Figure 5 is a section of the chain taken on the line B-B of Figure 3.

Where possible throughout the following description the same parts or members as referred to in each of the Figures have been accorded the same references.

The transmission system which is incorporated in the embodiments of Figures 1 and 3 is the same and is similar to that system which is described in our U.K. Patent Specification No. 1,426,351 with reference to Figure 2 thereof.

Referring firstly to Figures 1 and 2 the assembly has a driving pulley 1 and a driven pulley 2. The pulley 1 has a fixed half sheave 3 which is keyed for rotation with an input shaft 4 and an axially displaceable half sheave 5 which is axially slidable through a bearing sleeve 6 on the shaft 4. Axially slidable pin and socket couplings 7 connect the displaceable half sheave 5 with the fixed half sheave 3 for rotation therewith. The axially displaceable half sheave 5 is biased axially towards the fixed half sheave 3 by a helical coil spring 8 which reacts between the half sheave 5 and a flange plate 9 keyed for rotation with the shaft 4. The driven pulley 2 has a fixed half sheave 10 which is keyed for rotation with an output shaft 11 and an axially displaceable half sheave 12 which is axially slidable through a sleeve 13 on the shaft 11. The axially displaceable half sheave 12 is connected through axially slidable pin and socket couplings 14 with the half sheave 10 for rotation therewith. In accordance with conventional practice shafts 4 and 11 are parallel and the half sheaves have drive faces 15 which on the respective pulleys 1 and 2 are opposed to provide those pulleys with substantially "V" formations within which an endless transmission member 16 is received.

Associated with the displaceable half sheave 12 is a centrifugal governor 17 comprising a cage plate 18 which is keyed for rotation with the shaft 11 and has a substantially frusto conical ramp surface 19 which is concentric with the shaft 11. Captured between the ramp surface 19 and radially extending tracks 20 formed in the half sheave 12 are balls 21. The balls 21 are radially displaceable along the tracks 20 from a maximum radially outer position in which they are shown in Figure 1 to a radially inner position indicated by the ghost line 21'. The balls 21 together with the biasing effect of spring 8 which reacts on the driven pulley 2 through the transmission member 16 determine the axial spacing between the half sheaves 10 and 12 and thereby of the half sheaves 3 and 5. By this latter control, if the biasing of spring 8 is sufficient to displace the half sheaves 3 and 5 axially towards each other and thereby displace the transmission member 16 radially outwardly to increase the radius R1 at which the member 16 drivingly engages with the pulley 1 then there is a corresponding reduction in the radius R2 at which the transmission member 16 drivingly engages the pulley 2 (which necessitates in the half sheave 12 being displaced axially away from the half sheave 10 which is permissible by the balls 21 being displaced radially inwardly along their respective tracks 20 and over the ramp surface 19 to, or towards, the position indicated at 21').

With both shafts 4 and 11 stationary the spring 8 will cause the transmission member 16 to be displaced radially for the balls 21 to be located at their radially innermost positions 21' and this will correspond to the radius R1 being at a maximum and greater than the radius R2 which will be at a minimum. If, from this latter condition, the shaft 4 is rotated at a progressively increasing speed, the output shaft 11 will be driven through the two pulleys and the transmission member 16 until the output shaft attains a predetermined speed of rotation at which the centrifugal force on the balls 21 causes them to be displaced radially outwardly and the half sheave 12 thereby to be displaced axially towards the half sheave 10 to radially displace the transmission member 16 against the biasing of spring 8 (so that R2 progressively increases whilst there is a corresponding decrease in R1). The ratio at which is transmitted between the pulleys 1 and 2 is in proportion to the radii R1 and R2 so that the rotational speed of the driven pulley 2 will be $\frac{R1}{R2}$ times the rotational speed of the driving pulley 1. By appropriate selection of the biasing strength of spring 8, the angle of the ramp surface 19 and the size of the balls 21, the rotational speed of the output shaft 11 as compared with that of the input shaft 4 can be controlled to provide predetermined characteristics; the most useful of those characteristcs will likely be to maintain the rotational speed of the output shaft 11 sub-

stantially constant irrespective of the speed at which the input shaft 4 is rotated within a predetermined range. This latter arrangement is useful in, for example, motor vehicles where the input shaft 4 can be rotated at varying speeds in accordance with the engine speed of the vehicle while the output shaft 11 is desirably rotated at constant speed to drive auxiliary apparatus of the vehicle such as a fluid pump or a generator.

The shafts 4 and 11 are respectively mounted by ball bearings 22 and roller bearings 23 in a sealed housing 24 formed by two casing parts 24*a* and 24*b* which are secured and sealed together by bolts 25 and a gasket 26. The sealed housing 24 contains a traction fluid through a film of which the transmission member 16 drivingly engages the drive faces 15 of the respective pulleys 1 and 2. In the present embodiment the traction fluid is the material sold under the Trade Name "Santotrac" made, as aforementioned, by Monsanto Limited.

In the embodiment of Figures 1 and 2 the transmission member 16 is an annular steel ring (see Figure 2) which is of rectangular shape (see Figure 1) in a section taken in a plane which includes the axes of shafts 4 and 11. During traction driving engagement between the annular ring 16 and the pulleys 1 and 2 and also during radial displacement of the ring 16 between its inner and outer limits as indicated at 16 and 16' in Figure 2 such drive is by arcuate line engagement along the radially inner edges (which may be chamfered) of the ring 16 and the drive faces 15 of the pulleys. However, since a film of the traction fluid is maintained between the drive faces 15 and edges of the ring member 16 wear on these and the edges of the ring member 16 wear on these [illegible] negligible and so both the drive faces of the pulleys and the transmission ring should exhibit long life.

From Figure 2 it will be seen that the housing 24 must have a relatively large internal diameter to accommodate the annular ring 16 and the radial displacement thereof. A large volume housing can be an inconvenience, especially if the transmission assembly is to be installed in a motor vehicle where limited space may be available for its location, and to alleviate this the transmission member 16 can be in the form of an endless chain as shown in the embodiments of Figures 3 to 5. From Figure 3 it will be seen that the dimensions of the housing 24 are considerably less than those of the housing in the Figure 2 embodiment and other than for different housing and different form of transmission member 16, the embodiment in Figure 3 can be regarded as identical in operation and construction to that in Figure 1. The chain 16 is of steel and is formed by alternate female ended links 27 and alternate male ended links 28 which are assembled together in male/female relationship and pivotally connected by pins 29. In Figure 3 part only of the chain linkage is shown as a matter of convenience; however, the linkage of the chain 16 is such that the pivotal interconnections retain the deformable loop of the chain in a flat plane (that is in the plane of the drawing of Figure 3). As shown in Figures 4 and 5 the chain may be regarded as having, in section, a substantially rectangular shape, particularly the female ended links 27, and the traction driving engagement between the chain and the drive faces 15 of the V-pulleys is effected through the inner peripheral side edges 16*a* (which may be chamfered) of the links 27 along arcuate lines similarly to the Figure 1 embodiment. The previously mentioned rigidity of the chain which maintains its loop in a flat plane ensures that the chain cannot become twisted along its length and thereby offset from the edge engagement with the drive faces 15 as shown in Figure 4.

Conveniently the input shaft 4 is rotatable by a V-belt drive through a wheel 30 (see Figure 1) from, for example the crank shaft of a vehicle engine or alternatively by direct drive, for example, through a dog clutch on the vehicle engine while the output shaft 11 can drive auxiliary equipment at substantially constant speed through a conventional V-belt take off from wheel 31.

CLAIMS

1. A transmission assembly of the kind specified in which the endless transmission member is of a substantially rigid metallic material and is in the form of a chain or annular ring member, and wherein the two V-pulleys are mounted in a sealed housing containing a traction fluid through a film of which fluid said transmission member is in traction driving engagement with both pulleys.

2. A transmission assembly as claimed in claim 1 in which the traction fluid is a cycloaliphatic synthetic hydrocarbon fluid.

3. A transmission assembly as claimed in either claim 1 or claim 2 in which the transmission member is a chain formed of pivoted links which are rigidly interconnected in the sense that the deformable loop of the chain is maintained in a substantially flat plane.

4. A transmission assembly as claimed in any one of the preceding claims in which drive through the film of traction fluid between the transmission member and each of the drive faces of the pulleys provides substantially arcuate line engagement.

5. A transmission assembly as claimed in any one of the preceding claims in which the transmission member is of substantially rectangular section in a plane which includes the axes of the shafts and wherein a side of said rectangular section is substantially parallel with the axes of the shafts so that the two inner peripheral edges of the transmission member respectively engage in line contact, through the traction fluid, one with each of the two drive faces of each pulley.

6. A transmission assembly as claimed in any one of the preceding claims in which the endless transmission member is formed in steel.

7. A transmission assembly of the kind specified and substantially as herein described with reference to Figures 1 and 2 of the accompanying illustrative drawings.

8. A transmission assembly of the kind specified and substantially as herein described with reference to Figures 3 to 5 of the accompanying illustrative drawings.

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